CLAIMS

The invention claimed is:

1. An image segmentation method, said method comprising:
    a) obtaining pixel attribute data for a mixed-content image;
    b) identifying a text region in said image;
    c) identifying a background region in said image;
    d) analyzing areas in said image outside any of said background regions and outside any of said text regions to identify contone regions;
    e) analyzing said contone regions to identify any text regions present within said contone regions;
    f) analyzing said contone regions to identify any background regions present in said contone regions;
    g) analyzing areas in said contone regions outside any of said background regions and outside any of said text regions to identify contone sub-regions; and
    h) repeating steps e-g until no further sub-regions are found.

2. An image segmentation method as described in claim 1 further comprising analyzing said contone regions and said contone sub-regions to identify pictorial contone regions.

3. An image segmentation method as described in claim 1 further comprising filtering said pixel data to remove noise.

4. An image segmentation method as described in claim 1 further comprising morphological processing of any of said text regions and any of said background regions to eliminate small isolated regions.

5. An image segmentation method as described in claim 1 further comprising connected component labeling.

6. An image segmentation method as described in claim 1 further comprising computing a bounding box for a region.

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7. An image segmentation method, said method comprising:

a) obtaining pixel attribute data for a mixed-content image, said pixel attribute data comprising at least one of a luminance data, a chrominance data and a hue data;

b) downsampling said pixel data;

c) filtering said pixel data to remove noise;

d) computing a local feature to identify a text region in said image;

e) analyzing a luminance histogram of said image to identify a background region in said image;

f) labeling any background regions as such;

g) applying morphological processing to said background regions and said text regions;

h) analyzing areas in said image outside any of said background regions and outside any of said text regions to identify contone regions;

i) analyzing said contone regions to identify any text regions present within said contone regions;

j) analyzing said contone regions to identify any background regions present in said contone regions;

k) analyzing areas in said contone regions outside any of said background regions and outside any of said text regions to identify contone sub-regions;

l) repeating steps e-g until no further sub-regions are found; and

m) analyzing said contone regions and said contone sub-regions to identify pictorial contone regions.

8. An image segmentation method as described in claim 7 wherein said morphological processing is erosion.

9. An image segmentation method as described in claim 7 wherein said morphological processing is opening.

10. An image segmentation method, said method comprising:

a) obtaining pixel attribute data for a mixed-content image, said pixel attribute data comprising at least one of a luminance data, a chrominance

data and a hue data;

b)   downsampling said pixel data;

c)   filtering said pixel data to remove noise;

d)   computing a local discriminating feature to identify a text region in said image;

e)   analyzing a luminance histogram of said image to identify a background region in said image;

f)   labeling any background regions as such;

g)   analyzing areas in said image outside any of said background regions and outside any of said text regions to identify contone regions;

h)   analyzing said contone regions to identify any text regions present within said contone regions;

i)   analyzing said contone regions to identify any background regions present in said contone regions;

j)   analyzing areas in said contone regions outside any of said background regions and outside any of said text regions to identify contone sub-regions;

k)   repeating steps e-g until no further sub-regions are found; and

l)   analyzing said contone regions and said contone sub-regions to identify contone regions and non-contone regions.

11. An image segmentation method as described in claim 10 wherein said local discriminating feature is a standard deviation.

12. An image segmentation method as described in claim 10 wherein said local discriminating feature is spread.

13. An image segmentation method, said method comprising:

    a)   obtaining pixel attribute data for a mixed-content image, said pixel attribute data comprising at least one of a luminance data, a chrominance data and a hue data;

    b)   downsampling said pixel data;

    c)   filtering said pixel data to remove noise;

    d)   computing a local discriminating feature, selected from the group consisting of standard deviation and spread, to identify a text region in said image, wherein a region is identified as text when said feature is above a local feature threshold value;

    e)   analyzing a luminance histogram of said image to identify a background region in said image, wherein a region is identified as background when an initial maximum histogram bin containing the highest number of pixels exceeds a background threshold value;

    f)   verifying said background region analysis using region chrominance data;

    g)   labeling any background regions as such;

    h)   analyzing areas in said image outside any of said background regions and outside any of said text regions to identify contone regions;

    i)   analyzing said contone regions to identify text regions present within said contone regions;

    j)   analyzing said contone regions to identify background regions present in said contone regions;

    k)   analyzing areas in said contone regions outside any of said background regions and outside any of said text regions to identify contone sub-regions;

    l)   repeating steps e-g until no further sub-regions are found; and

    m)   analyzing said contone regions and said contone sub-regions to identify pictorial contone regions and non-pictorial contone regions.

14. An image segmentation method as described in claim 13 wherein said local discriminating feature is standard deviation and said local feature threshold value is 32.

15. An image segmentation method as described in claim 13 wherein said

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background threshold value is related to image size.

16. An image segmentation method as described in claim 13 wherein said
    background threshold value is 12.5% of image size.

17. An image segmentation method as described in claim 13 wherein said
    identification of a background region is independent of image element
    color.

18. An image segmentation method as described in claim 13 wherein said
    identification of a background region further comprises progressively
    expanding said background region beyond said initial maximum
    histogram bin into neighboring histogram bins when said neighboring
    histogram bins contain a sufficient number of pixels.

19. An image segmentation method as described in claim 13 wherein said
    identification of a background region further comprises the use of a
    chroma foreground mask and a hue foreground mask.

20. An image segmentation method as described in claim 13 wherein said
    identification of contone regions comprises analyzing luminance
    histogram bins to determine the number of bins (N_{pop}) containing more
    pixels than a contone threshold value, wherein a region is considered a
    contone region when N_{pop} exceeds a uniformity threshold value.

21. An image segmentation method as described in claim 13 wherein said
    analysis to identify contone regions comprises verification using region
    properties.

22. An image segmentation method as described in claim 21 wherein said region
    properties comprise area.

23. An image segmentation method as described in claim 22 wherein a region is

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not regarded as contone when its area is smaller than the square of one tenth of the page width.

24. An image segmentation method as described in claim 13 wherein said analyzing to identify pictorial contone regions comprises eliminating the two histogram bins containing the highest number of pixels and analyzing the remaining bins for bi-modal distribution.

25. An image segmentation apparatus, said apparatus comprising:

a) a reader for obtaining pixel attribute data for a mixed-content image;

b) a text identifier for identifying a text region in said image;

c) a background identifier for identifying a background region in said image;

d) a contone analyzer for analyzing areas in said image outside any of said background regions and outside any of said text regions to identify contone regions;

e) wherein said text analyzer may analyze said contone regions to identify any text regions present within said contone regions;

f) wherein said background analyzer may analyze said contone regions to identify any background regions present in said contone regions;

g) wherein said contone analyzer may analyze areas in said contone regions outside any of said background regions and outside any of said text regions to identify contone sub-regions; and

h) wherein said text analyzer, said background analyzer and said contone analyzer may operate recursively on regions and sub-regions to identify nested regional attributes.

26. A computer-readable medium comprising instructions for:

   a)   obtaining pixel attribute data for a mixed-content image;

   b)   identifying a text region in said image;

   c)   identifying a background region in said image;

   d)   analyzing areas in said image outside any of said background regions and outside any of said text regions to identify contone regions;

   e)   analyzing said contone regions to identify any text regions present within said contone regions;

   f)   analyzing said contone regions to identify any background regions present in said contone regions;

   g)   analyzing areas in said contone regions outside any of said background regions and outside any of said text regions to identify contone sub-regions; and

   h)   repeating steps e-g until no further sub-regions are found.